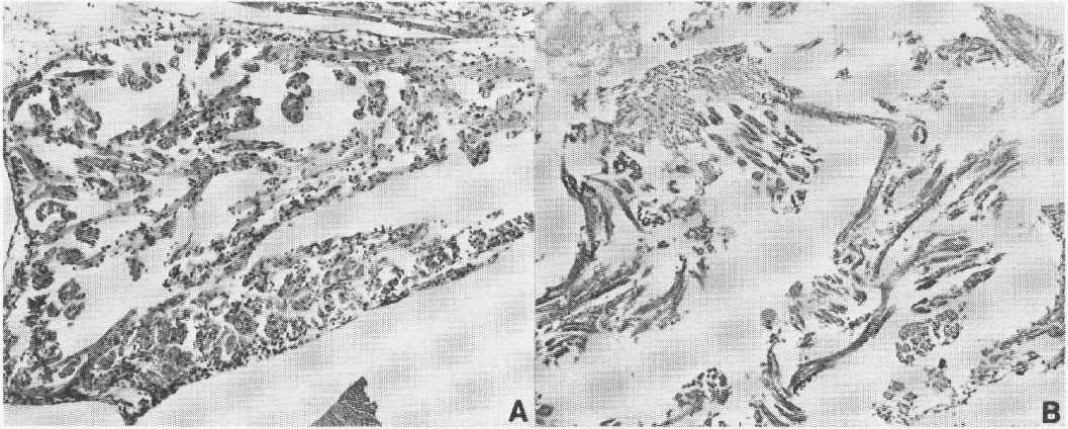

FIGURE 3.—**a.** Normal heart. 110×. **b.** Heart at 4 h postmortem showing considerable autolytic change and loss of structural detail. 100×.

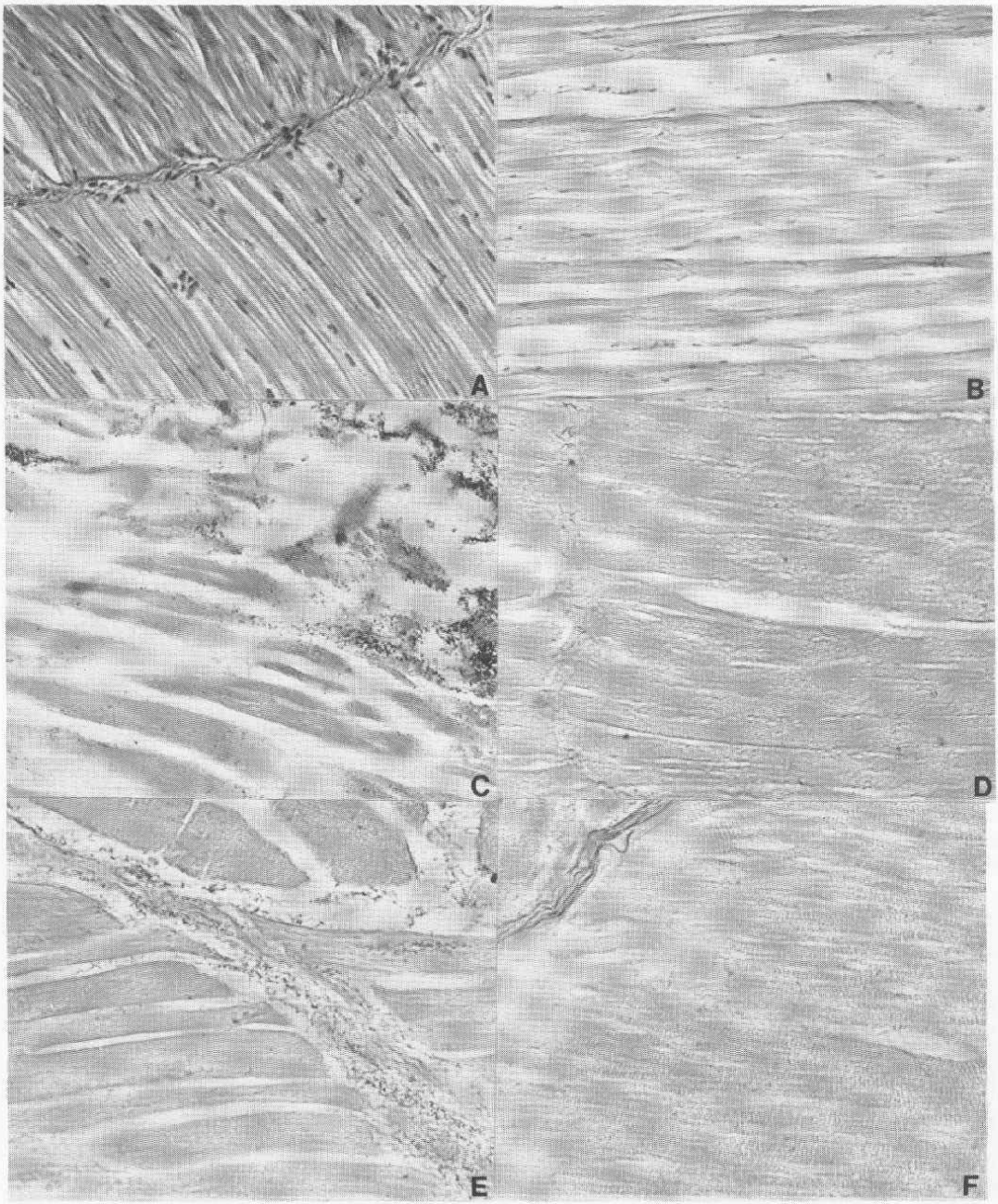

FIGURE 4.—**a.** Normal abdominal muscle. 220×. **b.** Muscle at 4 h postmortem showing edematous swelling between muscle bers. Sarcoplasmic staining reaction is more eosinophilic than normal and there has been a decrease in the number of nuclei although few pyknotic nuclei are shown. 150×. **c.** Muscle showing advanced autolytic change due to the presence of large amounts of bacteria (12 h postmortem). 190×. **d.** Muscle at 24 h postmortem. Edematous swelling has decreased, but the muscle fibers have become anucleate. Note the prominence of cross striations. 240×. **e.** Muscle at 48 h postmortem. 240×. **f.** Muscle fibers with prominent cross striations are still recognizable at 72 h postmortem. 250×.

the cuticle remaining by 4 h. Distant from the hepatopancreas, the epidermis showed pyknotic nuclei and cell rounding by 4 to 8 h (Figures 5a and 5b). A slight hemocytic response was present at this time in the subepidermal tissue layers representing the only inflammatory-like response observed in the study.

The epidermis had frequently become detached from the overlying cuticle by 12 to 24 h postmortem and many of the epidermal cells had lysed, with those remaining having pyknotic nuclei (Figure 5c). By 24 to 48 h nearly all traces of the epidermis had been lost and in some animals examined only cellular debris or clumps of bacteria marked its former location (Figure 5d). Though usually interrupted, the cuticle was the most resistant structure to autolytic change and showed only slight histological change by 72 h.

Gills

The shrimp respiratory system consists of paired gills in the branchial chambers of the cephalothorax. The structure of the gills is dendrobranchiate (Barnes, 1963). The gills are covered by a thin cuticle underlain by a thin epithelium and other supportive cells (Figure 6a).

A peritrichous ciliated protozoan (Figure 6b), presumably a commensal on shrimp (especially common on the gills but also found elsewhere on

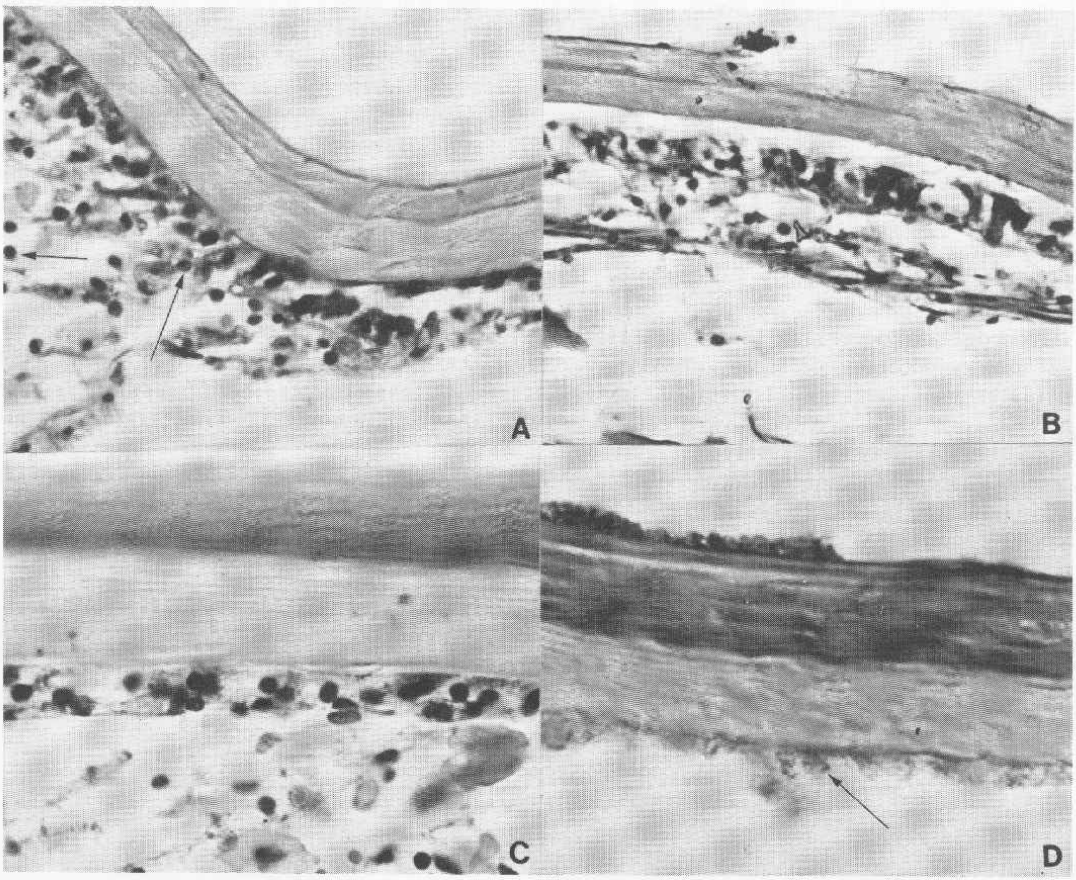

FIGURE 5.—**a.** Integument consisting of epidermis and overlying cuticle at 4 h postmortem. Some of the epidermal cells possess pyknotic nuclei. A few hemocytes are present in the subepidermal tissues (arrows). 480×. **b.** Integument at 8 h postmortem. Inflammatory cells are present in the subepidermal tissue. There is an increase in nuclear pyknosis in the epidermis and in the subepidermal tissue. 300×. **c.** Epidermis and cuticle at 24 h postmortem. All of the epidermal cells have intensely pyknotic nuclei, as does all the subepithelial tissue. 600×. **d.** Integument at 48 h postmortem. The cuticle is present, but the epidermis is represented by debris (arrows). 750×.

the body surface), increased rapidly in numbers for 2 to 4 h after death of the shrimp. They were absent by 8 h postmortem.

The cellular elements of the gills underwent fairly rapid autolytic change. By 8-12 h scattered pyknotic nuclei were present (Figure 6c). By 24 h the cellular elements of the gills were for the most part anucleate, with some portions of the gills having only eosinophilic debris within the lamellar cuticle (Figure 6d). By 48 h the thin cuticle of gill lamellae had begun to deteriorate and hence the gill lamellae sectioned transversely began to lose their typical "dumbbell" appearance (Figure 6e). By 72 h the gills were usually no longer demonstrable histologically, but in one of four animals examined portions of the gills were still evident (Figure 6f).

Nerve Tissue

The nervous system of shrimp is composed of a large ventral nerve cord and segmental ganglia from which smaller nerve branches originate to innervate the tissues. At the anterior end of the ventral nerve tract is the supraesophageal ganglion, which anteriorly receives the large optic nerve tracts.

Neuron perikaryons in the ganglia (Figure 7a) underwent the most rapid autolytic change of the various elements of shrimp nerve tissue. After 2 to 4 h, these cells showed considerable rounding, pyknotic or karyolytic nuclei, and a change in cytoplasmic staining from highly basophilic to a lesser basophilic to almost eosinophilic (Figure 7b). By 8 h no trace of neuron perikaryons was evident.

The nerve tracts of the ventral nerve, its branches, and the optic nerves autolyzed less rapidly than did neuronal perikaryons. However, nerve cell processes (axons and dendrites) within the nerve tract autolyzed more rapidly than did the supportive neurolemmal and glial cells, and were no longer demonstrable histologically by 12 to 24 h (Figure 7c). The supportive glial cells of the nerve tracts persisted without noticeable change to 8 to 12 h, but these cells became anucleate or underwent autolysis after 24 h, and their former presence was represented only by debris and an occasional pyknotic nucleus (Figure 7d).

After 24 h postmortem, the basic structural arrangement of the nerve tract remained recognizable due to the persistence of neurolemmal fibers (Figures 7d and 7e), which persisted to 72 h at the sites of the optic nerve and ventral nerve tracts.

Antennal Gland

The antennal gland of crustaceans had been demonstrated to be important in ion regulation (Robertson, 1959). The antennal or hemocoelic excretory gland in shrimp is located in the cephalothorax above the supraesophageal ganglion (Young, 1959). The gland is composed of a collection of tubules and a bladder (Figures 8a and 8b). By 4 h some sloughing of tubule epithelium was evident (Figure 8b), but for the most part the histologic appearance of the organ remained normal. At 12 h, however, most of the nuclei of the tubule epithelium were intensely pyknotic (Figure 8c), and by 24 h the organ had disappeared or had become difficult to recognize (Figure 8d). No trace of the gland was found after 48 h postmortem.

Gonadal Tissue

Since the animals used in this study were immature juvenile shrimp, the gonads were small, poorly differentiated and were located in the cephalothorax lateral and slightly caudad to the hepatopancreas. The terminal ampule of male shrimp was poorly developed and in female shrimp the ovarian lobe, which extends into the abdomen in older shrimp, had not yet developed.

The rate of autolysis in the gonads of the shrimp studied was rapid, due to their close proximity to the hepatopancreas. Gonadal tissue was not recognizable histologically after 4 to 8 h postmortem.

DISCUSSION

The rigorlike stiffening observed in this study may represent true rigor mortis. Sparks (1972) postulated that rigor mortis or a similar phenomenon may occur in some invertebrates with well organized skeletal systems and associated skeletal muscles. He based his opinion on the observation that many arthropods, which are flaccid after somatic death, subsequently